Comparative Study of Early Outcomes and Complications of Laparoscopic vs Open Repair for Perforated Duodenal Ulcers

Dr. Harish Chauhan[1], Dr. Jignesh Savsaviya[2], Dr. M. Hamzah Vhora[3]

[1]M. S., F. I. A. G. E. S., F. M. A. S., F. I. C. P. S.), Additional Professor, Department of General Surgery, SMIMER, Surat, Gujarat, India

[2]M. S., F. M. A. S., F. I. A. G. E. S., F. I. C. P. S.), Assistant professor, Department of General Surgery, SMIMER, Surat, Gujarat, India

[3]3RD Year Resident Doctor, Department of General Surgery, SMIMER, Surat, Gujarat, India

Abstract: ***Background**: There is great controversy regarding the choice of procedure for perforated duodenal ulcer patients. The purpose of this study was to compare the early outcome results of laparoscopic and open repair and to propose which risk factors influence the outcome. **Methods**: Between January 2009 and June 2021, 60 patients underwent laparoscopic and 162 patients under - went open repair of perforated peptic ulcers in SMIMER Hospital. The results were retrospectively analysed. The primary outcome measures included operative time, duration of hospital stay, morbidity, and mortality. **Results**: The operative time was significantly longer in the laparoscopy group compared to the open repair group (76.2 ± 35.3 vs 57.3 ± 26.1 min, respectively). The hospital stay in surviving patients appeared to be significantly shorter after laparoscopy than after open repair (7.8 ± 5.3 vs 10.3 ± 10.6 days, respectively). Eight patients (13%) in the laparoscopic group and 41patients (25%) in the open repair group had morbidity in the postoperative period. Suture leakage was confirmed in four patients (7%) following laparoscopic repair and in three patients (2%) in the open repair group. There were 20 deaths (9%), all in the open repair group. **Conclusions**: Independent Boey risk factors, patient age, and large perforation size have a negative impact on patient recovery. Both laparoscopic and open repair are equally safe and effective in perforated duodenal ulcer patients with a Boey score of 0or1.***

Keywords: Peptic ulcer perforation — Laparoscopy —Open repair—Treatment outcome—Post operative complications—Risk factors

1. Introduction

Laparoscopic repair for perforated duodenal ulcer was first described in 1990 [12]. Following the initial report there were many publications stating the efficacy and safety of laparoscopic repair [3, 4, 6, 9, 10, 14–16].

There is no doubt about the advantage of laparoscopic repair in terms of better cosmetics [5]. It is also believed that the re is a lesser incidence of postoperative adhesions and hernias following the minimally invasive approach (al - though there are no evidence - based data) [5]. However even in light of the previously mentioned advantages laparoscopic repair should not be chosen at the expense of higher morbidity and mortality. Thus, it is vital to compare the early outcome results following the conventional and laparoscopic repair methods.

Laparoscopic repair for perforated duodenal ulcer has gained only partial acceptance because the advantages of the minimally invasive approach are not completely obvious [5]. Some authors have stated that laparoscopic repair is the procedure of choice [6, 9, 14–17], whereas others have failed to prove its advantages [1, 8, 10, 13] or even backed the traditional approach in the case of peritonitis [11]. However, a recently published meta - analysis reported that the laparoscopic approach is the procedure of choice in low - risk patients [5]. None - the less, there is uncertainty regarding the morbidity rates in the high - risk group following the two different approaches. The risk factors influencing the outcome must also be clarified. The purpose of this study was to com - pare the results of open and laparoscopic repair and to propose which risk factors influence the outcome.

2. Materials and methods

All patients who underwent laparoscopic or open simple closure for perforated duodenal ulcer in SMIMER hospital between January 2009 to June 2021 were retrospectively analysed. The comparison groups were defined as open and laparoscopic repair patients. Decisions regarding the method of repair (laparoscopic or open), as well as the need for conversion, were entirely dependent on the individual surgeon's preference, opinion, and expertise.

Patients

There were 363 surgeries registered for perforated peptic ulcers: 64laparoscopic and 299 open. Of these, there were 164 simple ulcer closures, 104 definitive repairs and 31 ulcer excisions.

There were two patients with gastric ulcers in the laparoscopy group and two patients in the open simple ulcer closure repair group who were excluded from this study. Two more patients were excluded from the laparoscopy group after the analysis of operative protocol. Laparoscopy was performed for diagnostic purposes without the intention to close the perforation site. Ultimately, 60 patients in the laparoscopic repair group entered the final analysis. There were 14cases (23.3%) of conversion from laparoscopic to open repair. Ulcer excision and definitive repair patients were excluded from the open repair group, leaving 162 simple closure patients in the open repair group.

Table 1: Demographic data for laparoscopic and open repair groups

Variable	Laparoscopic repair (n=60)	Open repair (n=162)	P value
Age (yr)	34.0±14.2	43.8±21.4	0.003[a]
Gender	Male, 55 (92%)	Male, 114 (70%)	0.007[b]
	Female, 5 (8%)	Female, 48 (30%)	
ASA I	21 (35%)	45 (27%)	0.007[a]
II	36 (60%)	73 (45%)	
III	3 (5%)	25 (15%)	
IV	0	14 (9%)	
V	0	5 (3%)	
Shock on admission	1 (2%)	13 (8%)	0.119[c]
Duration of perforation	3 (5%)	29 (18%)	0.015[b]
>24h			
Boey score 0	54 (90%)	114 (70%)	0.001[a]
1	5 (8%)	18 (11%)	
2	1 (2%)	22 (14%)	
3	0	8 (5%)	
Ulcer size (mm)	4.1±2.5	5.6±5.3	0.025[a]
Peritonitis Diffuse	52 (87%)	139 (86%)	0.869[a]
Local	8 (13%)	23 (14%)	
Duration of perforation (h)	8.6±11.1	16.5±26.1	0.009[a]
Ulcer history	12 (20%)	45 (28%)	0.239[b]
Previous abdominal surgeries	5 (8%)	33 (20%)	0.034[b]

aMann - Whitney test
[b]chi - square test
[c]Fisher's exact test

Study sample

Patient groups were compared according to 11 preoperative variables (Table1). According to eight of the measured variables the groups were not comparable: open repair patients were significantly older and presented with higher risk according to American Society of Anaesthesiology (ASA) and Boey score longer duration of symptoms, larger perforation size and a higher rate of previous abdominal surgery history (p<0.05). Thus, to enable a meaningful comparison of the two approaches, patients were stratified according to Boey score into different risk groups within the laparoscopic and open repair groups (Table2). For 169 patients, no Boey risk factors were reported (Boey score0); only eight patients had Boey score 3 (all in the open repair group). After the stratification, the patients within the groups were comparable. Only one significant difference was observed: patients with Boey score 1 were significantly older in the open repair group.

Terms

A repair that was initiated laparoscopically with the intention to treat a perforated duodenal ulcer was considered to be laparoscopic failure to close the perforation site laparoscopically resulted in conversion to open repair.

Shock on admission was defined as a systolic blood pressure less than 100 mmHg with evidence of insufficient perfusion to other organ systems. The duration of perforation was considered the time lag between the onset of acute abdominal symptoms and the start of the surgery. If it was more than 24h, it was considered prolonged. Operative time was calculated as the time between the start of incision and the complete closure of the skin. Grade III, IV, and V surgical risk according to ASA score meant serious confounding medical illness. Boey score (0–3) is the count of Boey risk factors shock on admission, ASA grade III–V, and prolonged perforation. A Boey score of 0 means low surgical risk, otherwise it is considered a high surgical risk.

Laparoscopic repair technique

Under general anesthesia, the patient is placed in a 15–20° reverse Trendelenburg position. The operating surgeon stands on the patient's left. A surgeon assistant stands on the right side. Through a 2 - cm - long infra umbilical incision, the carbon dioxide pneumoperitoneum (up to12 mmHg) is established with a Veress needle. After establishing the pneumoperitoneum, the laparoscope is introduced through a 10 - mm trocar and the whole abdominal cavity is thoroughly investigated. If the preliminary diagnosis is not rejected, additional trocars are placed under laparoscopic control, including a trocar in the epigastrium used for liver and gallbladder retraction and the two most important working trocars on the left side—a 12 - mm trocar in the upper left quadrant in the subcostal region on the left midclavicular line or slightly lateral and a 5 - mm trocar where the left midclavicular line meets the inferior border of the left upper quadrant or slightly lower. After the ulcer size is carefully measured with reference to the 5 - mm - diameter working laparoscopic instrument, the perforation is closed using a 12 - mm trocar with a single, double, or triple PDS or Vicryl separate stitch repair technique. The ulcer edges are approximated by extra corporeal knotting. In six patients (10.0%) an omental patch (omentopexy) over the sutured site was used for reinforcement. The methylene blue test was used in 18 patients (30%) and the air–fluid leakproof test in 11 patients (18%). Both of these tests were used only in the laparoscopy group. Thorough peritoneal lavage was performed using 3–6 L of warm normal saline with the patient in various positions. Special attention was given to supra hepatic and sub hepatic spaces lateral channels and the left sub diaphragmatic and pelvic cavities. The peritoneal cavity was always drained. One, two, or three drains were used, depending on the extent of peritonitis. The operations were performed by a team of 13 surgeons who had 10 years of experience in laparoscopic cholecystectomies and appendectomies and who had undergone laparoscopic suture training.

Decisions regarding the technical aspects of each laparoscopic operation, as well as the need for conversion, were entirely dependent on the individual surgeon's preference, opinion, and expertise. Technical details were documented in a surgical protocol Open repair was performed using the classic ulcer closure with omentopexy

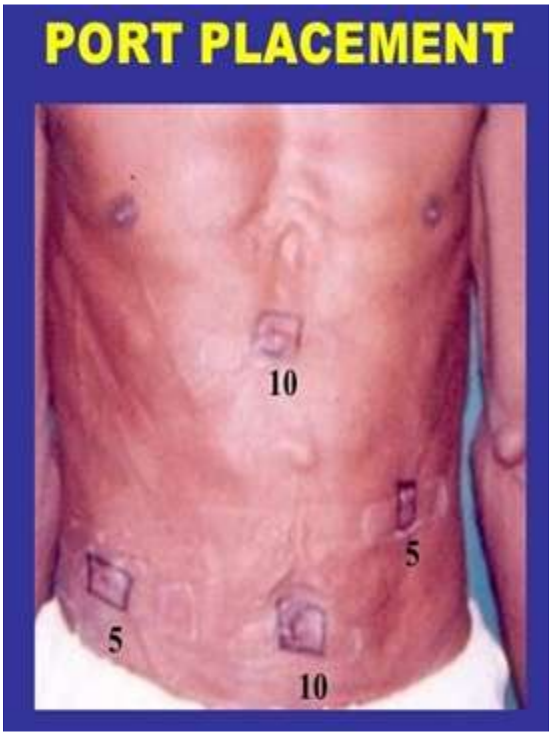

Table 2: Demographic data for laparoscopic and open repair groups after risk stratification

Boey score	Variable	Laparoscopic repair	Open repair	*P* value
0	No. of patients Age (yr)	54 33±12.2	114 33±12.9	0.897[a]
	Gender	Male, 51 (94%)	Male, 99 (87%)	0.137[b]
		Female, 3 (6%)	Female, 15 (13%)	
	ASA I	20 (37%)	44 (39%)	0.846[b]
	II	34 (63%)	70 (61%)	
	Shock	0	0	
	Duration of perforation>24h Ulcer size (mm)	0 4.2±2.6	0 4.3±2.3	0.696[a]
	Peritonitis Diffuse	47 (87%)	98 (86%)	0.850[b]
	Local Duration of perforation (h)	7 (14%) 6.5±4.3	16 (13%) 6.4±3.9	0.908[a]
	Ulcer history	11 (20%)	36 (32%)	0.131[b]
	Previous abdominal surgeries	5 (9%)	23 (20%)	0.076[b]
1	No. of patients Age (yr)	5 34.6±21.5	18 69.9±17.9	0.001[b]
	Gender	Male, 4 (80%)	Male, 3 (17%)	0.017[d]
		Female, 1 (20%)	Female, 15 (83%)	
	ASA I	1 (20%)	1 (6%)	0.080[c]
	II	2 (40%)	3 (17%)	
	III	2 (40%)	8 (44%)	
	IV	0	5 (28%)	
	V	0	1 (6%)	
	Shock	1 (20%)	0	0.217[d]
	Duration of perforation>24h Ulcer size (mm)	2 (40%) 3.6±1.3	4 (22%) 5.9±3.1	0.576[d] 0.150[c]
	Peritonitis Diffuse	4 (80%)	15 (83%)	1.000[d]
	Local Duration of perforations (h)	1 (20%) 23.6±29.1	3 (17%) 20.4±19.8	0.755[a]
	Ulcer history	1 (25%)	2 (11%)	0.539[d]
	Previous abdominal surgeries	0	6 (33%)	0.272[d]
2	No. of patients Age (yr)	1 80±0	22 68.7±14.7	0.522[c]
	Gender	Male, 0	Male, 9 (41%)	1.000[d]
		Female, 1 (100%)	Female, 13 (59%)	

	ASA			
	I	0	0	0.696[c]
	II	0	0	
	III	1 (100%)	15 (68%)	
	IV	0	4 (18%)	
	V	0	3 (14%)	
	Shock	0	5 (23%)	1.000[d]
	Duration of perforation>24h	1 (100%)	17 (77%)	1.000[d]
	Ulcer size (mm)	5 ±0	10.2±11.1	0.909[c]
	Peritonitis			
	Diffuse	1 (100%)	19 (86%)	1.000[d]
	Local	0	3 (14%)	
	Duration of perforation (h)	48±0	49.2±35.1	0.783[c]
	Ulcer history	0	5 (23%)	1.000[d]
	Previous abdominal surgeries	0	2 (9%)	1.000[d]
3	No. of patients	0	8	
	Age (yr)	—	65.5±20.5	—
	Gender	—	Male, 3 (38%)	—
			Female, 5 (63%)	
	ASA			
	I	—	0	—
	II	—	0	
	III	—	2 (25%)	
	IV	—	5 (63%)	
	V	—	1 (13%)	
	Shock	—	8 (100%)	—
	Duration of perforation>24h	—	8 (100%)	—
	Ulcer size (mm)	—	12.7±5.6	—
	Peritonitis			
	Diffuse	—	7 (88%)	—
	Local	—	1 (13%)	
	Duration of perforation (h)	—	62.3±57.7	—
	Ulcer history	—	2 (25%)	—
	Previous abdominal surgeries	—	2 (25%)	—

[a]*t* - test,
[b]Chi - square test,
[c]Mann - Whitney test,
[d]Fisher's exact test

Table 3: Outcome results in laparoscopic and open repair groups

Outcome measure	Laparoscopic repair	Open repair	*P* value
Operative time (min)	76.2±35.3	57.3±26.1	0.000[a]
Hospital stay (d)	7.8±5.3	10.3±10.6	0.000[a]
Postoperative morbidity	8 (13%)	41 (25%)	0.056[b]
Suture leakage	4 (7%)	3 (2%)	0.087[c]
Intraabdominal abscess	2 (3%)	1 (1%)	0.178[c]
Dynamic ileus	2 (3%)	2 (1%)	0.296[c]
Fistula	1 (2%)	1 (1%)	0.468[c]
Pneumonia	3 (5%)	9 (6%)	1.000[c]
Pneumothorax	1 (2%)	0	0.270[c]
Reoperation	5 (8%)	3 (2%)	0.035[c]
Mortality	0	20 (12%)	0.004[c]

[a]Mann - Whitney test
[b]Chi - square test
[c]Fisher's exact test

Postoperative management

Perioperatively all patients received intravenous fluids, nasogastric tube decompression, parenteral analgesics (100 mg tramadol and 100 mg diclofenac), antibiotics, and pantoprazole in standard doses. In the normal postoperative course, the nasogastric tube was removed after 48 h, oral fluids were resumed on postoperative day 3, and solid dietary meals were introduced on postoperative day4.

Data collection

Patients' records were located and collected using the local computer network. After an initial assessment of patients'records, it was decided that it would be reasonable to take into consideration 19 variables: age, gender, shock on admission, peritonitis (either diffuse or local), duration of ulcer perforation (i. e., acute abdominal symptoms), ASA grade, Boey score (i. e., the count of Boey risk factors: shock on admission, confounding medical illness, and prolonged perforation), number of previous abdominal surgeries and their locations, ulcer disease history (positive or negative), ulcer localization, ulcer size, duration of operation, conversion, reason for conversion, additional procedures during laparoscopic repair (omentopexy, dye test, and air–fluid test), post - operative complications, outcome, and duration of hospital stay. Data were entered into a database using Microsoft Access.

Statistical analysis

For descriptive purposes, discrete (quantitative) variables were expressed as counts and percentages, and continuous (quantitative) variables were expressed as means with standard deviations. Categorical variables were tested with a two - tailed Fisher's exact test if more than 20% of the cells in the frequency tables had expected frequencies below 5. Continuous data were compared using an independent samples *t* distribution test (equal variances assumed) and a Mann - Whitney test. The test of choice depended on the variance, which was compared using the Levene's test of equality. If the variance was found to be significantly different from the two independent samples ($p< 0.05$; Levene's test of equality) the Mann - Whitney test was employed. The Mann - Whitney test was also used for categorical ordinal data (e. g., ASA). All statistical tests were two - tailed; $p < 0.05$was considered significant. Multifactorial analysis for discrete variables (i. e., conversion and morbidity) was performed using a logistic regression test. For quantitative data (i. e., hospital stay), a linear regression test was employed. The statistical package SPSS 10.0 for Windows was used.

3. Results

Early outcome results before stratification are reported in Table3. Operative time was significantly longer in the laparoscopic repair group. Hospital stay was shorter following the minimally invasive approach. Although the reoperation rate was lower in the open repair group the mortality rate was higher. Patients were stratified into different risk groups, and the early outcome results are reported in

Table 4: Outcome results in laparoscopic (Lap.) and open repair groups after risk stratification

Boey score	0		1		2		3	
Operative approach	Lap (*n*=54)	Open (*n*=114)	Lap (*n*=5)	Open (*n*=18)	Lap (*n*=1)	Open (*n*=22)	Lap (*n*=0)	Open (*n*=8)
Operative time(min)	76.8±36.0	51.1±19.7	61.0±19.9	72.6±40.9	120±0	70.7±23.5	–	74.3±38.7
Hospital stay(d)	7.8±5.5	8.0±2.1	6.6±2.3	17.8±12.9	14.0±0	23.3±27.8	–	23.7±13.6
Postoperative morbidity	6(11%)	11(10%)	1(20%)	9(50%)	1(100%)	15(68%)	–	6(75%)
Suture leakage	3(6%)	0	1(20%)	0	0	2(9%)	–	1(13%)
Intraabdominal abscess	2(4%)	0	0	1(6%)	0	0	–	0
Dynamic ileus	2(4%)	2(2%)	0	0	0	0	–	0
Fistula	2(4%)	0	0	0	0	1	–	0
Pneumonia	2(4%)	2(2%)	0	4(22%)	1(100%)	3(14%)	–	2(25%)
Pneumothorax	1(2%)	0	0	0	0	0	–	0
Reoperation	4(7%)	0	1(20%)	2(11%)	0	2(9%)	–	0
Mortality	0	0	0	5(28%)	0	10(46%)	–	5(63%)

Operative time

Unifactorial analysis demonstrated that operative time was significantly increased by choosing the laparoscopic approach in patients with Boey score 0 (76.8±36.0vs51.1 ± 19.7 min, respectively; Mann - Whitney test). The data were comparable in the Boey score 1 and 2 groups. Multifactorial analysis using linear regression test revealed five independent risk factors for prolonged operative time: conversion, large perforation size, diffuse peritonitis, laparoscopic approach (as opposed to open repair) and shock on admission. The other proposed risk factors—ASA, duration of perforation, Boey score, and omentopexy were not significant.

Hospital stay

In low - risk patients and the Boey score 2 group, length of hospital stay was comparable, whereas for the Boeyscore1 group, hospital stay was significantly shorter in the laparoscopy group ($p = 0.007$, Mann - Whitney test) Multifactorial analysis employing the linear regressiontest demonstrated that prolonged hospital stays could be predicted by the following five risk factors: postoperative suture leakage, large perforation size, postoperative pneumonia, delayed surgery, and postoperative abdominal complication. The other proposed risk factors, conversion, ASA, ulcer history, diffuse peritonitis, duration of perforation, age, gender, shock on admission, Boey score, omentopexy, antibiotic use, air–fluid test, dye test, operative time, operative approach (open vs laparoscopic) —were not significant risk factors.

Postoperative morbidity and reoperation rates

The overall morbidity rates for the laparoscopic and open repair groups were comparable (Table3) However, after patient stratification, suture leakage was confirmed to be significantly higher in the low - risk group (Boey score 0) ($p = 0.032$, Fisher's exact test). Subsequently, it caused a significantly higher reoperation rate in the low risk group ($p = 0.010$, Fisher's exact test). There were no statistically significant differences regarding the suture leakage rate in the high - risk groups: Boey score 1 ($p = 0.217$Fisher's exact test) and Boey score 2 ($p = 1.000$, Fisher's exact test). There were also no statistically significant differences concerning the reoperation rate: Boey score1 group (p=0.539Fisher's exact test) and Boey score2 group (p=1.000Fisher's exact test).

Multifactorial analysis, employing the logistic regression test (Table 5), confirmed that overall morbidity was influenced by the duration of perforation and patient age. The other proposed risk factors were not significant.

Table 5: Risk factors for overall complication rates

Risk factor	P value	Odds ratio	95%CI min	95%CI max
Prolonged perforation	0.003	1.079	1.026	1.136
Age	0.046	1.034	1.001	1.068

Mortality

There were no deaths reported in laparoscopy patients. However, there were 20 mortality cases in open repair. The difference did not reach statistical significance in the Boey score1group (p=0.363, Mann - Whitney test). Multifactorial analysis employing the logistic regression test (Table 6) found that high ASA evaluation and high Boey score resulted in a significantly increased mortality rate. The choice of surgical approach did not seem to influence mortality rates.

Table 6: Risk factors for mortality, 95% CI

Risk factor	*p* value[a]	Odds ratio	min	max
ASA	0.051	6.356	0.988	40.878
Boey score	0.032	11.308	1.230	103.945

4. Discussion

There are only a few studies comparing laparoscopic and open repair, and very few of these have a study sample of more than 100 patients [6, 7, 15, 16]. The size of our study sample (222 patients) was much larger than that of most studies. However, only 56 of our patients (including only five laparoscopic) had one or more Boey risk factors. This can be explained by the surgeon's preference to rely on the better mastered open repair for high - risk patients. Thus, a type II error of logic is likely (to accept the null hypothesis when it is wrong). This is especially true for the Boey score 1 and 2 groups. In addition, patients with Boey score 1 were significantly older in the open repair group. Theoretically, this could preclude appropriate comparison between laparoscopic and open repair in our study. Thus, the results of our study are more reliable for patients with no Boey risk factors.

After patient stratification into different surgical risk groups, intragroup analysis concludedthe early outcome results for the laparoscopic and open methods are comparable. Three differences were demonstrated: longer operative time and higher suture leakage (and subsequently higher reoperation rates) in laparoscopy patients with Boey score 0 and shorter hospital stays inlaparoscopypatientswithBoeyscore1.

On the other hand, there were no deaths reported in the laparoscopy group. In addition, the overall suture leakage rate was only 5%. Also, all the suture leakage cases were reported for surgeons who had previously performed less than 10 laparoscopic suture closures; thus, these cases obviously could be attributed to the learning curve. Second, although the suture leakage rate and reoperation rate are significantly higher in the laparoscopy Boey score 0 group, a logistic regression test denied the significance of the surgical approach.

The 9 - day difference in hospital stay between laparoscopic and open repair in the Boey score 1 group is clinically significant. Regarding the laparoscopic operative time, modern irrigation equipment and experience in laparoscopy seem to decrease it [16]; thus, this dis - advantage of the minimally invasive approach can potentially be overcome. Also, converted cases were included under the laparoscopy group, which favoured open repair in our study.

Better cosmetics following laparoscopy remains unquestionable. It is also believed that fewer postoperative adhesions and incisional hernias occur in laparoscopy patients [5]. Further studies are needed to compare the late follow up results (ulcer recurrence, incisional hernias, and adhesions) following deferent surgical approaches.

The results of our study are slightly in agreement with the data reported by Lau [5] in his literature meta - analysis. Longer operative time, higher reoperation rate, and shorter hospital stay in the laparoscopic group were demonstrated in his study as well as in ours. Suture leakage rates favoured open repair, although this was insignificant in the Lau study [5]. The significantly higher suture leakage rates in our study may be attributed to the learning curve.

The usefulness of the risk stratification system proposed by Boey et al. [2] in predicting morbidity and mortality was shown in Lee et al. 's [7] study. The same authors confirmed the correlation between Boey score and postoperative morbidity and mortality: Morbidity rates increases progressively with increasing Boey score— 17.4, 30.1, and 42.1% for Boey scores of 0, 1, and 2, respectively. The mortality rates in Lee et al.'s [7] study were1.5, 14.4, 32.1, and 100% for Boey scores of 0, 1, 2, and3, respectively.

In addition, our study demonstrated the usefulness of the Boey scoring system for research purposes. Independent Boey risk factors, such as ASA evaluation, delayed presentation, and shock on admission, were shown by our multifactorial analysis to influence the results. In addition, patient age and large perforation size had a negative impact on patient recovery.

5. Conclusion

Our study shows that both laparoscopic and open repair are equally safe and effective in perforated duodenal ulcer patients with Boey scores of 0 or 1. Keeping this in mind, higher priority should begiven to the minimally invasive approach in these patients.

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